

heavy shore ends were covered with strands of wire instead of simple wires. Mr. Siemens proposed to apply a covering of hemp outside the iron wires and to wrap this round with a zinc armor.

(To be continued.)

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Pile Driving. By CHAS. H. HASWELL, Civil and Marine Eng., N.Y.

The effect of the blow of a ram, or monkey, of a pile-driver, is as the square of its velocity, but the impact is not to be estimated directly by this rule, as the degree and extent of the yielding of the pile materially affects it. The rule, therefore, is of value in application only as a means of comparison.

By my experiments in 1852, to determine the *dynamical* effect of a falling body, it appeared that whilst the effect was directly as the velocity, it was far greater than that usually estimated by the formula $\sqrt{s} 2g$, which, for a weight of 1 lb. falling 2 feet, would be 11.34, giving a momentum of 11.34 ft. lbs., whereas by the effect shown by the following record of actual observation, it would be $v w 4.426 = 50$ lbs.

Results of experiments made to determine the dynamical effect of bodies falling freely, 1852.

Weight of falling body, avoirdupois.	Space fallen through.	Velocity acquired at end of fall, per second.	Effect as indicated by instrument.
lbs.	feet.	feet.	lbs.
.5	.5	5.67	12.5
.5	1.	8.02	17.75
.5	2.	11.34	25.
.5	3.	13.89	31.
.5	4.	16.04	36.
.5	5.	17.93	40.
1.	.5	5.67	25.
1.	1.	8.02	35.5
1.	2.	11.34	50.
1.5	.5	5.67	37.
1.5	1.	8.02	53.
2.	.5	5.67	50.
2.	1.	8.02	71.5

Piles are distinguished according to their position and purpose; thus, *gauge piles* are driven to define the limit of the ground to be enclosed, or as guides to the permanent piling.

Sheet or close piles are driven between the gauge piles to form a continuous enclosure of the work.

The weight which is required of each pile to sustain should be computed as if it stood unsupported by any surrounding earth.

When the length of an oak pile does not exceed sixteen times its

diameter, it may be loaded permanently with a weight of 450 lbs. per square inch of its sectional area.

A heavy ram and a low fall is the most effective condition of operation of a pile driver, provided the height is such that the force of the blow will not be expended in merely overcoming the inertia of the pile, and, at the same time, not from such a height as to generate a velocity which will be expended in crushing the fibres of the head of the pile.

The *refusal* of a pile intended to support a weight of $13\frac{1}{2}$ tons can be safely taken at ten blows of a ram of 1350 lbs., falling 12 feet, and depressing the pile four-fifths of an inch at each stroke.

Pneumatic Piles.—A hollow pile of cast iron, $2\frac{1}{2}$ feet in diameter, was depressed into the Goodwin sands 33 feet 7 inches in $5\frac{1}{2}$ hours.

Nasmyth's Steam Pile Hammer has driven a pile 14 inches square, and 18 feet in length, 15 feet into a coarse ground, imbedded in a strong clay, in 17 seconds, with 20 blows of the hammer, or monkey, making 70 strokes per minute.

By the extended observations of Brevet Major John Sanders, U.S. Engineers, he deduced the following rule whereby to estimate the weight that can be safely borne upon a pile: "As many times the weight of the ram, as the distance which the pile is sunk, the last blow is contained in the distance which the ram falls in making the blow, divided by 8," which, when reduced to a formula, becomes

$$\frac{(R \times h \div d)}{8} = w,$$

R representing the weight of the ram in pounds, *h* the height of the fall, and *d* the distance the pile is depressed by the blow, both in feet.

Here, then, is obtained a formula whereby to compute the limit of operation of a driver, which is essentially all that is required.

Illustration.—A ram, weighing 3500 lbs., falling $3\frac{1}{2}$ feet, depressed a pile 4.2 ins. Then,

$$\frac{3500 \times (42 \div 4.2)}{8} = \frac{35000}{8} = 4375 \text{ lbs.},$$

the weight which the pile would bear with safety.

By the ordinary formula $\sqrt{v \ 2g} \ w$, $15 \times 3500 = 52,750$ lbs., the computed force; hence, assuming the rule of Major Sanders as a guide, $\frac{4375}{52,750} = .0814$, which may be taken as the co-efficient whereby to reduce the momentum of a ram to the weight the pile can bear with safety.

Messrs. M. Scott and J. Robertson submitted to the Institution of Mechanical Engineers, London, 1857, a paper on the "Theory of Pile Driving," of which the following are the essential points, when briefly given, viz:

The object of the investigation of pile driving is not to determine to a fraction of an inch the distance a pile may be driven, and especially so, as the resistance offered by the earth, which is the most im-

portant element, cannot be correctly ascertained, but the object is to elicit the simple and general truths upon which the system depends.

Dr. Whewell deduced—

1. A slight increase in the hardness of the pile, or in the weight of the ram, will considerably increase the distance the pile may be driven.

2. The resistance being great, the lighter the pile the faster it may be driven.

3. The distance driven varies as the cube of the weight of the ram.

Although these deductions cannot be depended upon as exact under all circumstances, they give a tolerably correct indication, and are in accordance with those which may be arrived at by general reasoning. The complication in the original expressions arises from taking into consideration in the general question the weight and inertia of the pile. The weight of the pile bears so small proportion to the resistance of the earth, that it may be neglected; for a pile 25 feet in length and 1 foot square weighs about one-half a ton, and if the fall of a ram weighing one ton is 10 feet, and the distance driven by the blow is 2 inches, then the resistance of the earth will be to the weight of the ram as 120 inches to 2 inches; that is, it will be 60 tons, of which one-half a ton is the $\frac{1}{120}$ part, and may, therefore, be neglected.

To Compute the Space through which a Pile is Driven.

$\frac{R h}{C} = s$, C representing the resistance of the earth. Hence, by inversion,

To Compute the Co-efficient of the Resistance of the Earth.

$$\frac{R h}{s} = C.$$

Weisbach gives the following formula: The resistance of the bed of earth being constant, the mechanical effect expended in the penetration of the pile will be—

$$\frac{R^2 h}{P + R s} = W.$$

Taking the elements of the preceding case, with the addition of the weight of the pile at 1500 lbs., the result would be—

$$\frac{3500^2 \times 3.5}{1500 + 3500 \times (4.2 \div 12)} = \frac{42,875,000}{1750} = 24,500 \text{ lbs.}$$

The range for security is given from $\frac{1}{10}$ to $\frac{1}{100}$. Assuming, then, the rule of Major Sanders as correct, the deduction from this rule would be $\frac{1}{11}$.

Potez, ainé, and Thibaut's Boiler Feed.

From the Practical Mechanics' Journal, May, 1866.

This apparatus is a combination of the two inventions, one called the stokers' aid, (*aide-chauffeur*), and the other the self-acting clearing cock, (*purgeur automate*.) The former is the invention of M. Potez,